ANSI E1.19 - 2015
Recommended Practice for the use of Class A Ground-Fault Circuit Interrupters (GFCIs) intended for personnel protection in the Entertainment Industry

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ESTA has reverted to its original name, and this document has been rebranded with the current corporate name and logo. No changes have been made to the contents of the standard.

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Table of Contents

1 Scope and Exclusions

1.1 Scope

The scope of this document is to recommend a practice for the safe use of Class A Ground Fault Circuit Interrupters (GFCIs) on 120-240 VAC single and three phase 60 Hz circuits with current ratings of 100 ampere or below where the voltage to ground does not exceed 150 VAC (hereinafter referred to as 15 to 100 ampere, 120-240 VAC, single and three phase circuits). GFCIs are used for personnel protection in entertainment applications encompassing places of assembly; the production of film, video, and broadcast; theatrical productions; carnivals; circuses; fairs; and similar events in North America.

> Informational Note: Systems that are 230 VAC to ground (e.g., European power systems) are outside of the scope of the class A GFCI Standard (UL 943) so they are outside the scope of this E1.19 Recommended Practice.

1.2 Exclusions

1.2.1 Ground Fault Protection of Equipment

Ground Fault Protection of Equipment are designed to provide protection of equipment from line to ground fault currents by disconnecting all ungrounded conductors on a circuit where such a fault occurs. This protection is provided at fault current levels higher than those for GFCI protection for personnel. Ground Fault Protection is equipment protection not personnel protection and ground fault protection of equipment shall not be used anywhere in place of Class A GFCI protection where GFCI protection is required or desired.

1.2.2 Residual Current Devices (RCDs) and Earth Leakage Circuit Breakers (ELCBs)

Residual Current Devices (RCDs) and Earth Leakage Circuit Breakers (ELCBs) are terms used for circuit protection devices commonly used in Europe, Australia and other countries. These devices are considered personnel protection in some countries but not in the USA or Canada and do not meet the requirements of Class A GFCI for personnel protection. RCDs and ELCBs shall not be used to provide Class A GFCI protection for personnel.

> Informational Note: RCD and ELCBs can be used to mitigate ground fault risks on circuits where GFCIs are not required. These devices have higher trip thresholds and are frequently rated for higher voltages that would be outside of the scope UL 943, the GFCI standard.

2 Definitions

2.1 Class A GFCI: A device whose function is to provide personnel protection by de-energizing a circuit, or portion thereof when the fault current to ground exceeds 6 milliamps within a period of time established by the GFCI Standard. GFCI products that meet these requirements are referred to by Nationally Recognized Testing Laboratories (NRTLs) as Class A GFCIs.

2.2 Nationally Recognized Testing Laboratory (NRTL): An organization that is recognized by the United States Department of Labor's Occupational Safety and Health Administration (OSHA) in accordance with the requirements of 29 CFR 1910.7 "Definition and Requirements for a Nationally Recognized Testing Laboratory" that accepts equipment or materials and tests for safety, lists and labels accordingly. The equivalent status in Canada is a Standards Council of Canada Accredited Certification Body.

2.3 NEMA: National Electrical Manufacturers Association.

2.4 Underwriters Laboratories (UL): A Nationally Recognized Testing Laboratory that also writes safety standards through an open standards process.

2.5 Class A GFCI Standard: The harmonized, tri-national Standard for construction and testing of Class A GFCIs. The document was issued jointly by ANCE in Mexico as NMX J 520, CSA in Canada as CSA C22.2 No. 144.1-06 and in the United States by UL as UL 943. The Standard is accepted by Mexico, the Canadian Electrical Code and the US National Electrical Code (NFPA 70).

2.6 Listed: Equipment or materials included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products and whose listing states that either the equipment, or material meets appropriate designated standards or has been tested and found suitable for a specified purpose.

2.7 Utilization equipment: Equipment that uses electrical power to produce a desired effect such as light (luminaires), heat (cooking equipment), or motion (motors).

3 Entertainment industry application types defined

3.1 Assembly occupancies: Includes but not limited to convention centers, armories, municipal buildings, tents, gymnasiums, hotel ballrooms and churches intended for the assembly of 100 or more persons. (US National Electrical Code Article 518 and Mexico Electrical Code Article 518)

3.2 Theatres: All buildings or that part of a building or structure, indoor or outdoor, designed or used for presentation, dramatic, musical, motion picture projection, or similar purposes and to specific audience seating areas within motion picture television studios. These areas are within the scope of US NFPA 70 (National Electrical Code) Article 520, Mexico Electrical Code Article 520 and Canadian Electrical Code Section 44.

> Informational note: A covered outdoor stage area for the above purposes, even if it falls within a carnival, fair or amusement park area, is considered part of a theatre.

3.3 Carnivals, circuses, fairs, sporting events and similar events: The portable wiring and equipment for the above including wiring on all structures. These areas are within the scope of US NFPA 70 (National Electrical Code) Article 525, Mexico Electrical Code Article 525 and Canadian Electrical Code Section 66.

3.4 Motion picture studios and similar locations: Professional television and motion picture studios and exchanges, factories, laboratories and stages. These areas are within the scope of US NFPA 70 (National Electrical Code) Article 530, and Mexico Electrical Code Article 530. Excluded are audience areas of television and motion picture studios that are considered part of a theatre.

3.5 Outdoor filming of motion picture, TV or video: An outdoor location used in the production of a motion picture, television or video production excluding areas open to the general public.

4 Class A GFCI products

4.1 Response time

The GFCI standard, UL 943, specifies a maximum response time to open the circuit that is a function of the detected ground fault current. The permissible response time can be in the range from virtually instantaneous to 5.59 seconds if the current is 6 mA. As the fault current increases the maximum allowable time to open a circuit decreases, with a response time less than 0.56 seconds being required at 30 mA compared to 5.59 seconds at 6 mA. The conventional wisdom is that the faster the response times the better, but GFCIs with fast response times are susceptible to nuisance tripping in electrically noisy environments.

In electrically noisy environments, such as those with harmonic currents described in clause 4.3, GFCIs with slower response times may avoid nuisance tripping. It is recommended that GFCIs used in electrically noisy environments have response times that are at least 50% of the permissible response

times described in UL 943 for fault currents at least up to 40 mA. If no devices are available in this range, any permissible delay will likely reduce nuisance tripping.

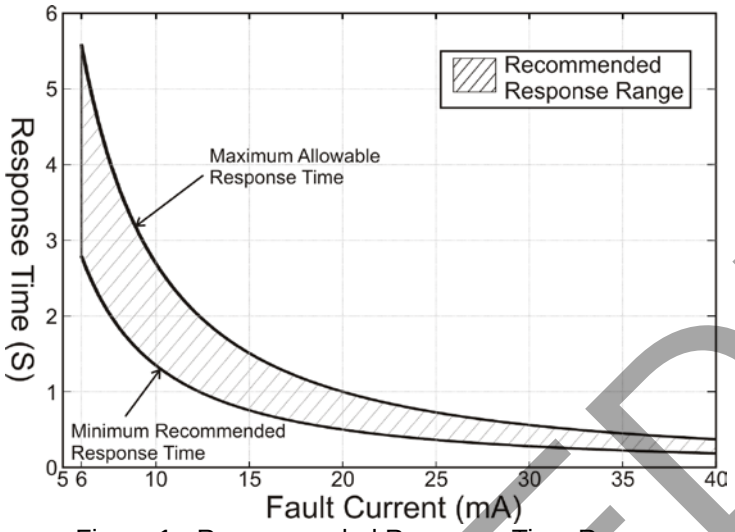

Figure 1 - Recommended Response Time Range

4.2 Types of products

This section outlines the types of products that are commercially available to achieve Class A GFCI protection in an electrical installation. Class A GFCI products must be Listed by a NRTL to the Class A GFCI Standard, UL 943. The products must bear the appropriate Listing mark of the NRTL.

4.2.1 Listed GFCI circuit breakers

Circuit breakers are available with Class A GFCI protection from single–pole, 15 ampere, 120 VAC to two pole 60 ampere 120/240 VAC. GFCI circuit breakers provide Class A protection when mounted in a permanently installed electrical panel by a licensed electrician or in a Listed portable power distribution unit by the original equipment manufacturer. Single pole GFCI circuit breakers typically do not provide GFCI protection downstream if there is a circuit fault upstream of the GFCI circuit breaker such as open neutral on the circuit.

4.2.2 Listed GFCI duplex receptacles

Listed GFCI duplex receptacles are available in 15 and 20 ampere 120 VAC versions. They contain the GFCI circuitry, two NEMA 5-15 (15 ampere) or NEMA 5-20 (20 ampere) openings and test and reset buttons.

Listed GFCI Duplex Receptacles can be installed by a qualified electrician as part of the permanent wiring of a building, indoors or out. Original equipment manufacturers can also include them in Listed portable power distribution boxes.

4.2.3 Listed GFCI portable adapters, 15-100 ampere 120-240 VAC single or three phase

Listed 15-100 ampere 120-240 VAC single or three phase GFCI portable adapters typically consist of a male plug attached to portable cord feeding a GFCI device with test and reset buttons: and a portable cord passing through the device to a female connector.

In the 15 and 20 ampere units, the plug and connector are typically molded NEMA 5-15 or NEMA 5-20 configuration. A variety of connector configurations are available on units rated above 20 amperes.

Portable GFCIs of larger current ratings are versatile tools when it is desirable to provide GFCI protection to multiple receptacles. They will provide GFCI protection to any outlets on the load side of a circuit, thus reducing the number of GFCI devices required. However, multiple outlets will be affected when a trip occurs.

They are also a suitable method to provide protection to higher ampacity utilization equipment that requires up to 100 ampere circuits. For example, a 100 ampere, 120 VAC inline unit would be recommended to provide Class A GFCI protection to a 10 kW (10,000 watt) luminaire in a motion picture application.

4.2.4 Listed portable power distribution units with GFCI

A portable power distribution unit is an enclosure whose purpose is to convert a portable feeder or branch circuit cord or cable to smaller overcurrent protected branch circuits with outlets. The outlets may be GFCI type with test and reset buttons or outlets fed from GFCI modules with test and reset buttons in order to provide Class A GFCI protection.

4.2.5 Listed GFCI quad strings

A quad string is a popular method of distributing GFCI protected outlets in special event or convention applications. Typically a three phase 20 ampere plug (NEMA L21-20) is attached to a length of extra hard usage portable cord feeding a small portable outlet box with one or two GFCI protected outlets. The outlet box feeds a second and third box that is similarly equipped. The third box may feed a three phase 20 ampere female connector for feed through purposes. In this manner GFCI outlets can be spread out over a 50-foot, 100-foot, or even greater distance.

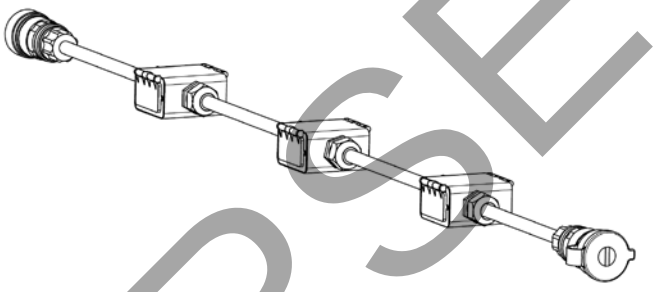

Figure 2 – Typical Quad String Assembly

4.3 Applications on Specialty Circuits

4.3.1 GFCI outlets on dimmed circuits

4.3.1.1 GFCIs on the output of dimmers

Standard GFCI duplex receptacles or receptacles fed by standard GFCI modules, shall not be connected to the load side of dimmed circuits. As the circuit is dimmed the voltage decreases and GFCI circuitry will not be able to operate at the reduced voltage. Using a standard GFCI on a dimmed system is a potentially dangerous condition because the GFCI may not switch off the circuit if there is a fault to ground. Dimmers are available with integral GFCI circuitry or GFCIs are available that have separate power leads to allow connection of control power separate from the circuit it is monitoring, thereby eliminating the potentially dangerous condition.

4.3.1.2 GFCIs feeding phase control dimmers

Phase-control dimmers create harmonic currents on the line and load sides of circuits. The GFCI may read this as a current difference and turn off the circuit, resulting in an open circuit where there was no fault current to ground. Dimmers can be special ordered with filters to reduce the harmonic current generated. Check with the dimmer manufacturer regarding specific models or applications.

4.3.2 GFCIs feeding electronic ballasts

Electronic ballasts for metal-halide and other discharge lamps may create harmonic currents in a circuit. The GFCI may read this as a current difference and turn off the circuit, resulting in an open circuit where there was no fault current to ground. Check with the ballast manufacturer, or the GFCI manufacturer, or

both, regarding specific models or applications that may avoid this condition.

5 Where to place GFCI protection

5.1 Wet Locations

The most conservative approach is provide Class A GFCI protection for all 15 to 100 ampere 120-240 VAC single and three phase receptacles and circuits feeding utilization equipment in wet locations, regardless of the application, but this may not be required by code. The use of GFCI shall be evaluated by a qualified person at the location. The evaluation includes all areas where water hazards exist such as situations where people, wardrobe, props, or equipment are wet.

> Informational Note: The presence of water will greatly increase the risk of shock hazard in an electrical circuit, when lighting or any other electrical equipment is used in close proximity to water.

5.2 Where not to use Class A GFCI devices

- Where the circuit or load involves egress or exit lighting.
- Where the circuit is part of an emergency system.
- Where removal of power will create a greater hazard.

6 Specific Recommendations for Entertainment Industry applications

6.1 Places of assembly

15A and 20A receptacles in the proximity of water shall have GFCI protection. Any electrical equipment supplying power to a pool, hot tub, or body of water shall have GFCI protection. Circuits larger than 20A in the proximity of water shall be evaluated for risk of shock hazard by a qualified person.

6.2 Theatres

6.2.1 Stage areas indoors

GFCI protection is recommended to be used on all 15 to 100 ampere 120-240 VAC receptacles and circuits in the proximity of water. Examples of situations involving water indoors and requiring GFCI protection would be a pool, hot tub, fountain, rain effect or sprinkler as part of a stage set.

6.2.2 Covered stages outdoors

A covered outdoor stage is considered a theatrical application, even if it is part of a larger fair or similar event. It is recommended that GFCI protection be provided for equipment and circuits that can be reached by water or rain.

6.2.3 GFCI protection for dimmers

If it is not possible to keep dimmers or dimmed circuits completely away from water, the circuits shall be GFCI protected. The GFCI unit protecting the dimmed circuit shall derive its power from a separate non-dimmed source or be a variable voltage GFCI. See sections 4.3.1 regarding GFCI protected dimmers.

6.3 Carnivals, circuses, fairs and similar events

6.3.1 Class A GFCI protection shall be used on all 15 to 20 ampere 120 VAC single phase outdoor receptacles. GFCI protection is not required for receptacles that are not accessible from grade level and that only facilitate quick disconnecting and reconnecting of electrical equipment shall not be required to be provided with GFCI protection. These receptacles shall be of the locking type.

6.3.2 Class A GFCI protection shall be used on all 15 to 100 ampere 120 to 240 VAC single and three phase receptacles where water is present. It is recommended that GFCI protection be provided for equipment and circuits that can be reached by water or rain.

6.3.3 Class A GFCI protection shall be used on all 15 to 30 ampere 120 VAC receptacles that are in use by personnel, such as receptacles supplying tools used in erecting or repairing carnival equipment.

6.3.4 Class A GFCI protection is required on 15 and 20 ampere, 120 VAC single phase receptacles, including indoor receptacles that are readily accessible to the general public.

6.3.5 Class A GFCI protection shall be used on all equipment that is readily accessible to the general public and supplied by 15 and 20 ampere, 120 VAC single phase circuits.

6.4 Motion picture and television studios, and Similar Locations

6.4.1 Wet Locations (Indoors and Outdoors)

Class A GFCI protection is recommended to be provided on all 15 to 100 ampere 120-240 VAC single and three phase receptacles and circuits in the proximity of water, including special effects employing water.

7 Successful implementation of a Class A GFCI system

7.1 Placement of GFCI units relative to the load

It is possible for lengths of cord or cable to exhibit characteristics of leakage that is read by the GFCI unit, contributing to nuisance tripping. Placing the GFCI unit close to the load (utilization equipment) will minimize nuisance tripping due to leakage from the cord or cable. This does not preclude placing GFCI units upstream to protect cord or cable.

> Informational note: Leakage levels from individual loads may meet the testing requirements for that type of load, and may not trip a GFCI when placed on a GFCI by itself, but multiple loads each with their own earth leakage levels will sum up if placed on the same GFCI. Dividing loads across multiple GFCIs, if additional GFCIs are available (e.g. two loads on two different GFCIs instead of two loads on the same GFCI), will reduce the likelihood of a GFCI tripping from the combined earth leakage of each individual device.

7.2 Preventive maintenance

Equipment owners such as rental houses, et cetera, would benefit from assuring the quality of their equipment by performing an off- line insulation resistance check as well as an on-line current leakage test on their equipment each time it is returned. See section 7.3 below for more detailed information regarding off-line and on-line testing.

7.3 Test electrical installations for ground-fault leakage

Testing electrical installations, whether permanent or temporary, for ground-fault leakage both before the circuit (or equipment) is energized and periodically thereafter is important for the proper and trouble free operation of the installation.

7.3.1 Off-line testing

Off-line (or de-energized) testing assures that a given circuit's insulation resistance to ground is of a sufficiently high value to ensure proper operation of the given circuit or given piece of equipment.

Off-line insulation testers superimpose a DC voltage of 500 V or higher between the load carrying conductors and ground. Such units measure for any DC leakage current that may flow. This test voltage may exceed the maximum voltage rating of some equipment, so it should be used only after considering the maximum voltage rating. Other methods exist for measuring insulation resistance.

> Informational note: As a rule-of-thumb, the minimum acceptable value of insulation resistance would be 1.0 MΩ (1 mega-ohm, or 1 million ohms). Most equipment manufacturers provide their own recommended minimum insulation level, often of a significantly higher value than the rule-of-thumb.

7.3.2 On-line measuring and monitoring

Periodic on-line measuring and monitoring for system ground-leakage assists staff and operators to determine that the system remains in good condition and should provide continued proper operation. Two readily available methods for on-line measuring and monitoring are periodic measuring and monitoring and continuous measuring and monitoring.

7.3.2.1 Periodic measuring and monitoring

Periodic measuring and monitoring may be performed using a clamp-on style ammeter with an accurate mA (milliamp) range and scale. The clamp-on style ammeter is used in two ways:

(a) by clamping around the load carrying conductors, or
(b) by clamping around the equipment or system ground conductor. With this method, it is very important that all exposed conductive parts are insulated from ground so that any ground fault current can flow only through the grounding conductor.

Periodic measuring and monitoring using the clamp-on style meter has its limitations. The clamp itself introduces a minute air-gap to the magnetic measuring circuit that often causes inaccuracies in the measurement.

7.3.2.2 Continuous measuring and monitoring

Continuous measuring and monitoring equipment is readily available. Certain Class-A GFCI manufacturers provide circuit and/or equipment leakage current measuring and monitoring indicators built into or with their GFCI products.

Continuous measuring and monitoring offers instant and simple access to circuit or equipment leakage conditions. It is inherently more accurate than clamp-on equipment due to its built-in, toroidal, non-air-gap style current transformer.

A leakage reading of 3 mA or above indicates that the circuit or equipment being monitored is leaking and is approaching the allowable leakage limit of the GFCI. Operators or technicians should start to look for the source of the ground leakage. Finding the cause of the leakage is performed by selective disconnection of equipment or feeders that are down-stream from the GFCI. When the defective circuit is disconnected or switched-off, the leakage current reading will be reduced. Proactive operators would start the process of ground-leakage elimination with lower readings (1-2 mA).

7.4 Inspecting and testing cords and cables

Portable cords and cables should be physically inspected for cracks or tears in insulation or thinning insulation that would allow leakage as well as electrically tested. See periodic measuring and monitoring for details.

8 Testing the GFCI installation

Class A GFCIs are to be tested when placed in use and every 30 days thereafter. Most jurisdictions require a written record of this testing. The “test” button shall be depressed, which should cause the GFCI to trip. Confirm that the protected outlet has been disconnected from the supply voltage. A listed GFCI testing device, test lamp, or voltage tester may be used to confirm that the protected outlet is disconnected. Devices that fail the test shall be removed from service immediately. Upon determination that the GFCI is performing correctly, the “reset” button shall be depressed to restore the circuit. For GFCI circuit breakers, there may be no reset button and the circuit breaker should be cycled back on.

The “test” and “reset” buttons are **NOT TO BE USED AS AN ON-OFF SWITCH** unless the GFCI is rated to be used as an on-off switch by the manufacturer.

Informational note: Some GFCI manufacturers may require factory maintenance for their products. Refer to the manufacturer's instructions for the GFCI device.